TM 11-6625-214-10

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

OPERATOR'S MANUAL
SIGNAL GENERATOR
AN/URM-52 AND AR/URM-52A

HEADQUARTERS, DEPARTMENT OF THE ARMY
OCTOBER 1960

HEADQUARTERS,
DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *13 October 1960*

TM 11–6625–214–10 (a reprint of Navy publication AN 16–30URM52–1, 15 May 1953) is published for the use of Army personnel.

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Seventh US Army (2)	11-500 (Tms AA-AE)	
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NG: None.

USAR: None.

For explanation of abbreviations used, see AR 320-50.

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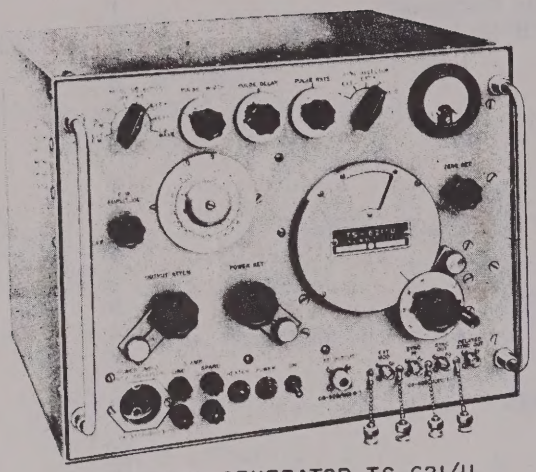
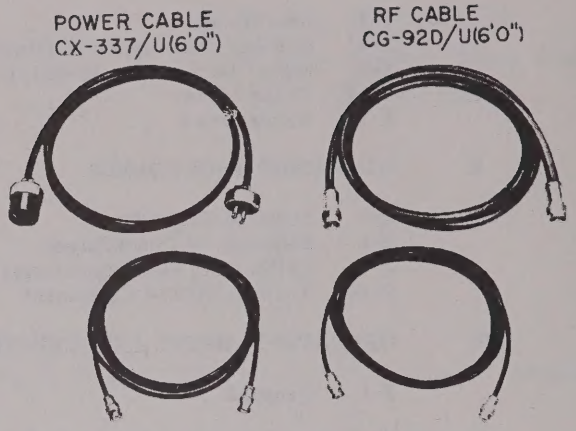
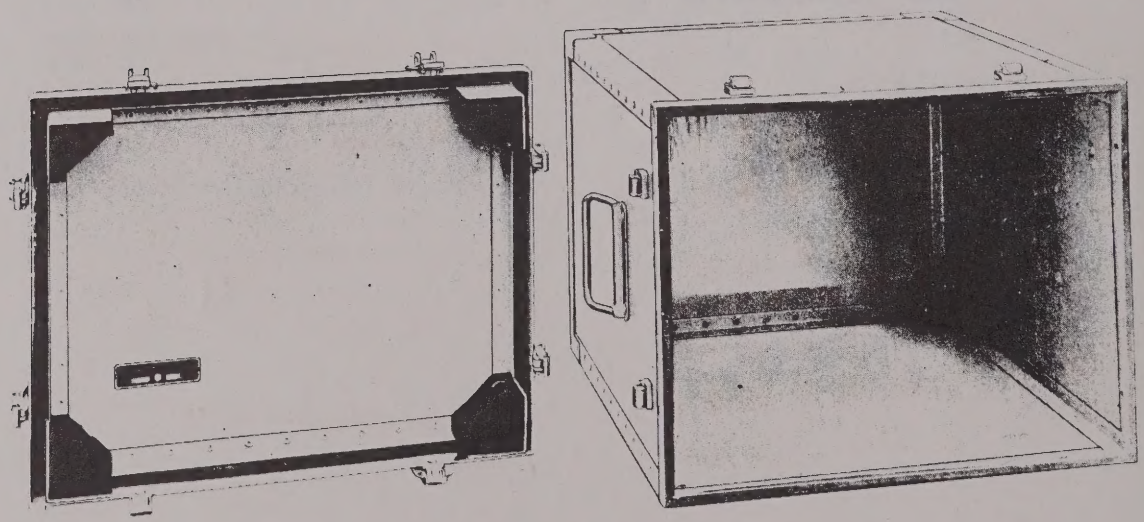


SIGNAL GENERATOR TS-621/U

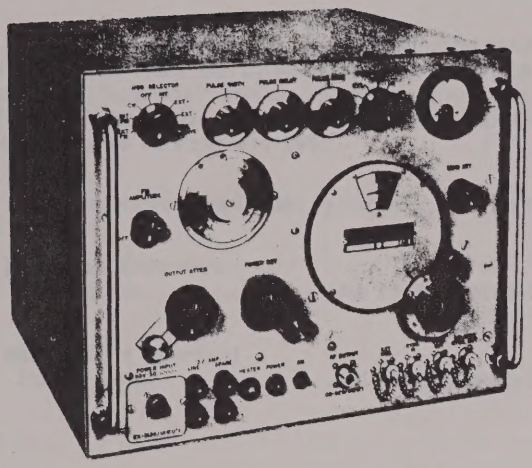


VIDEO CORDS CG-409/U(8'0")



TRANSIT CASE CY-1294/U

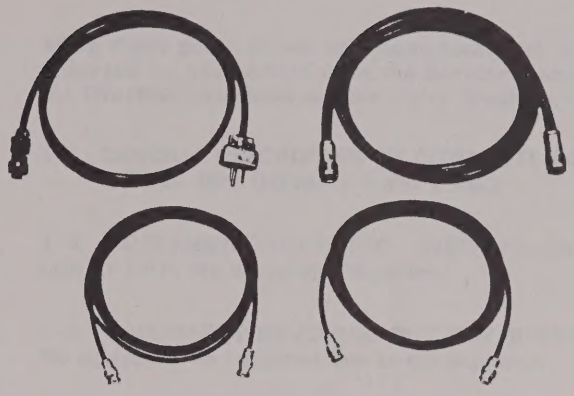
Figure 1-1. Signal Generator AN/URM-52, Equipment Supplied



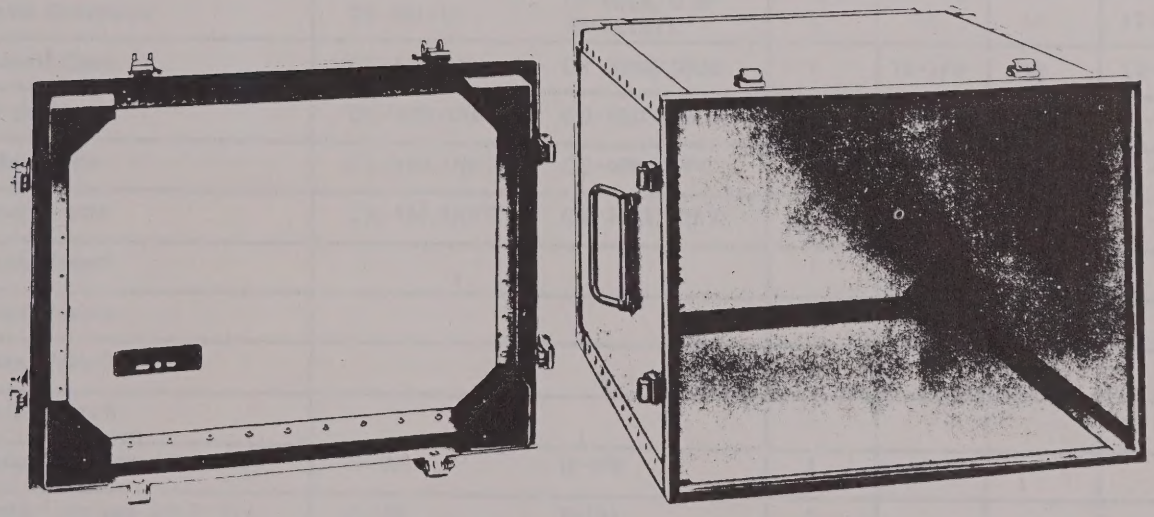
SIGNAL GENERATOR TS-621A/U
OR TS-621B/U

POWER CABLE
CX-3135/U(6'-0")

RF CABLE
CG-92D/U(6'-0")

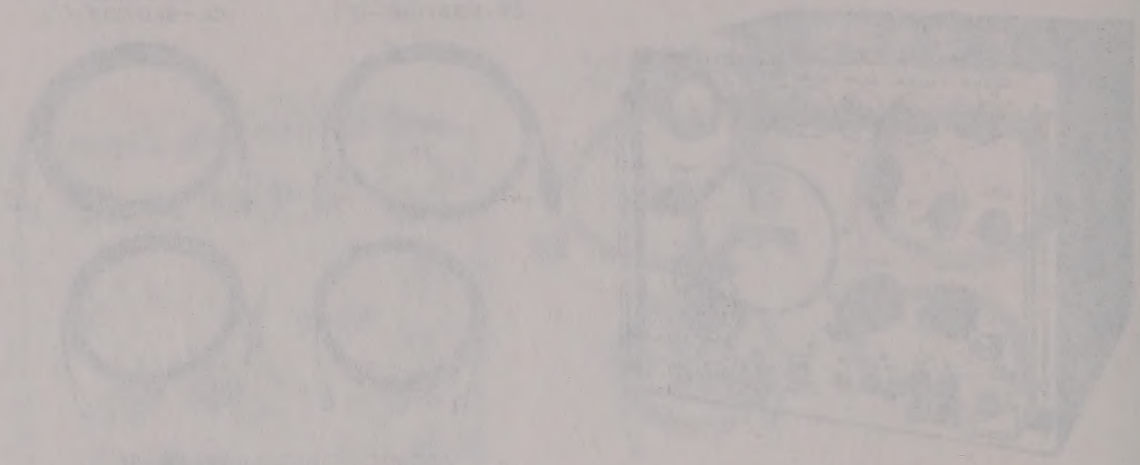


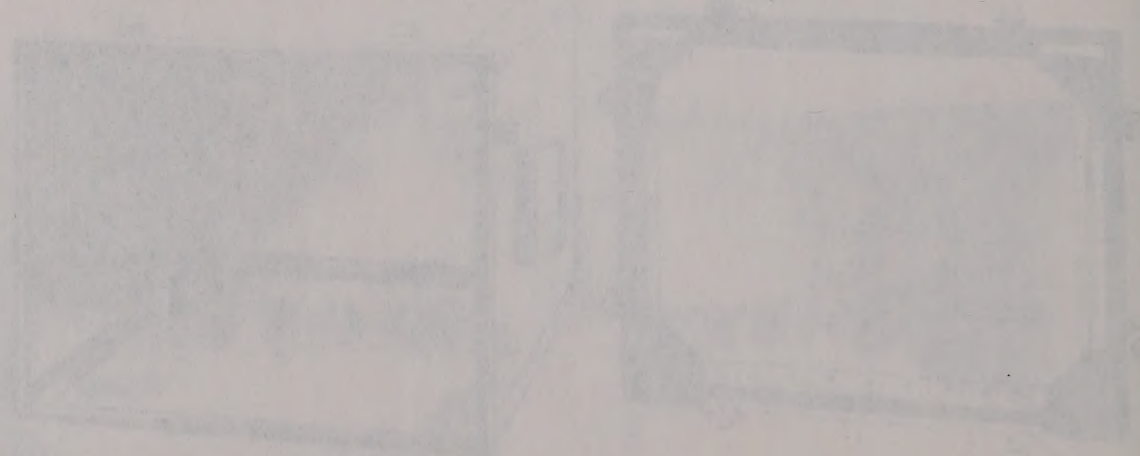
VIDEO CORDS CG-409/U(8'-0")



TRANSIT CASE CY-2109/URM-52A

Figure 1-1A. Signal Generator AN/URM-52A, Equipment Supplied





SECTION I

GENERAL DESCRIPTION

1-1. IDENTIFICATION. (See figures 1-1 and 1-1A.)

1-2. This handbook comprises operating instructions for Signal Generators AN/URM-52 and AN/URM-52A, manufactured by Hewlett-Packard Company, Palo Alto, California, in accordance with Specification MIL-G-7141(Aer), dated 15 February 1951.

1-3. Other publications applicable to this equipment are:

a. Handbook of Service Instructions . . . . . AN 16-30URM52-2

b. Handbook of Overhaul Instructions . . . . . AN 16-30URM52-3

c. Illustrated Parts Breakdown . . . . . AN 16-30URM52-4

When these publications are mentioned, they will be referred to, respectively, as the Service Handbook, the Overhaul Handbook and the Parts Breakdown.

1-4. GENERAL DESCRIPTION OF COMPLETE EQUIPMENT. (See figures 1-1 and 1-1A.)

1-5. EQUIPMENT SUPPLIED. Table 1-1 shows in tabular form the equipment supplied.

1-6. EQUIPMENT REQUIRED BUT NOT SUPPLIED. No equipment is required that is not supplied.

TABLE 1-1. EQUIPMENT SUPPLIED

Item	Signal Generator		Size (inches)			
	AN/URM-52	AN/URM-52A	Quantity	Length	Width	Height
Signal Generator	TS-621/U	TS-621A/U or TS-621B/U	1	17	14	17-5/8
Transit Case	CY-1294/U	CY-2109/URM	1	19-1/8	16	19-1/2
RF Cable	CG-92D/U(6'0")	CG-92D/U(6'0")	1	72	-	-
Video Cable	CG-409/U(8'0")	CG-409/U(8'0")	2	96	-	-
Power Cable	CX-337/U(6'0")	CX-3135/U(6'0")	1	72	-	-
Allen Wrench			1			
Allen Wrench			1			
Allen Wrench			1			
Allen Wrench			1			
Hexagonal Socket Wrench	H-105	H-105	1			
Contact Springs for V-114	0-155	0-155	2 (spares)			

1-7. GENERAL DESCRIPTION. (See figures 1-1 and 1-1A.) Signal Generators AN/URM-52 and AN/URM-52A are complete, self-contained signal generators. The main component of Signal Generator AN/URM-52 is Signal Generator TS-621/U. The main component of Signal Generator AN/URM-52A is either Signal Generator TS-621A/U or TS-621B/U. A watertight case is supplied for transporting and storing the signal generator, video cords, power and r-f cables, and spare klystron grid contact springs. Signal Generators TS-621/U, TS-621A/U and TS-621B/U are functionally identical. There are minor differences mechanically and in the circuits, but the signal generators may be used interchangeably. Each signal generator is housed in a removable dust cover. Stowed within each unit are small hand tools. The units are used for testing and calibrating various types of electronic equipment, and in other applications requiring small amounts of r-f power such as measuring standing waves, antenna and transmission line characteristics, conversion gain, etc., within their frequency range. The

radio frequency output may be continuous wave (CW), internally square wave modulated, or internally pulse modulated while either internally or externally synchronized, externally modulated with pulses or square waves, or frequency modulated either internally or externally. In addition to providing various types of radio frequency output, the signal generators also make available at designated connectors two synchronizing voltages, occurring at two different controllable instants in time, which may be used when synchronizing external equipment. The operating characteristics of the signal generators are fully described in paragraph 1-8. All the operating controls and connectors are located on the front panel of the equipment and are described fully in Section II. The equipment employs a blower for forced ventilation of the klystron oscillator tube. The radio frequency output is within the portion of the super-high frequency range from 3800 to 7500 megacycles per second. The frequency is selected by a single direct-reading control which is accurate to within ±1 percent of the indicated frequency. Its rated maximum power output is 0.1 milliwatt. However, the equipment is normally capable of providing up to 1.0 milliwatt of power. This extra power greatly increases the use of the generator for tests where up to 1.0 milliwatt of power is required. The power output is controlled by a direct reading attenuator, which is calibrated in decibels below 1 milliwatt (dbm) in the range of 0 to -127 dbm. The rated external load for the r-f output is 52 ohms. The input power requirements are 115 volt single phase 50 to 1000 cps alternating current at 2.1 amperes.

1-8. SIGNAL GENERATORS TS-621/U, TS-621A/U AND TS-621B/U.

NOTE

Throughout this handbook, references to the signal generator will include Signal Generators TS-621/U, TS-621A/U and TS-621B/U unless otherwise indicated.

1-9. TYPES OF R-F OUTPUT. The signal generator provides the following types of super-high frequency outputs:

a. Continuous (CW) unmodulated r-f output.

b. Internally modulated output.

1. Rectangular r-f output pulses developed by modulation from the internal square wave generator, with a repetition frequency adjustable from 40 to 4,000 pulses per second.

2. Pulsed r-f output developed by modulation from the internal pulse generator, with a pulse repetition frequency adjustable from 40 to 4,000 pulses per second and a pulse width adjustable from 0.5 to 10.0 microseconds. This output may be synchronized with the internal pulse generator, or by externally developed sine wave signals, or by positive or negative pulses with amplitudes of from 5 to 50 volts.

3. Saw-tooth frequency modulated r-f output, with a recurrence rate adjustable from 40 to 4,000 cycles per second and adjustable frequency deviation. The saw-tooth generator which modulates the r-f output may be either internally or externally synchronized.

c. Externally modulated output.

1. Pulses or square wave r-f output developed by externally applied positive or negative pulses having an amplitude of 15 to 70 volts, a pulse duration of 0.5 to 2,500 microseconds, and a pulse separation period of 1.0 to 2,500 microseconds.

2. Frequency modulated r-f output developed from externally applied sine wave or saw-tooth modulation voltages with a recurrence rate determined by the external source. The frequency deviation may be adjusted with the same control used for INT. FM operation. The maximum external modulating voltage which may be used depends upon the frequency of the r-f output of the signal generator. The following table shows the maximum external voltage which may be employed.

MAXIMUM EXTERNAL VOLTAGE FOR EXT. FM OPERATION

Frequency	Maximum Peak to Peak Voltage
Below 4000 mc	25 volts
4000 to 5000 mc	50 volts
Above 5000 mc	100 volts

1-10. OUTPUT SYNCHRONIZING SIGNALS. The signal generator also provides two external synchronizing signals for use when synchronizing external equipment. These are available when internal or external synchronizing signals for pulse type operation are employed. They are:

a. A positive voltage pulse occurring essentially at the same time as the start of the synchronizing signal. This pulse has an amplitude greater than 25 volts when connected to a load having a resistance of from 1000 to 100,000 ohms and a shunt capacitance of 500 micro-microfarads or less. The pulse width is approximately two microseconds.

b. A positive voltage pulse occurring essentially with the start of the r-f output pulse with any delay from 3 to 300 microseconds between the synchronizing pulse (either internal or external) and the modulation pulse applied to the radio frequency oscillator.

1-11. ELECTRICAL CIRCUITS. The electrical circuits of the signal generators are described in detail in the Handbook of Service Instructions, AN 30URM52-2 and reference should be made to Section IV, Theory of Operation of that publication for information beyond the scope of the following brief description. The signal generator has the following electrical circuits:

a. R-F OSCILLATOR. The basic super-high radio frequency oscillator circuit of the signal generator employs a type 6236 reflex klystron tube operating with a parallel-plane line resonator that is tunable over the frequency range of the equipment. The repeller voltage for the klystron is automatically tracked with the tuning plunger so that a single control determines both the resonant frequency of the line and the value of the repeller voltage. This system makes it possible to calibrate the tuning dial directly in frequency.

b. POWER MONITOR AND ATTENUATOR. The power level at the resonator is monitored at all times. This is accomplished by applying the radio frequency energy available at a pickup probe to a circuit which establishes the reference level of power in the resonator while simultaneously positioning the index scale located over the calibrated attenuator dial. Another pickup probe delivers radio frequency energy to the external load through the RF OUTPUT connector on the front panel. This probe is mechanically linked to the attenuator dial, and when the dial is read under the index position established by the Power Set control, the attenuation, indicated in decibels below one milliwatt, may be directly read over the entire range of the equipment.

c. INTERNAL PULSE CIRCUITS. The signal generator contains an internal pulse generator that establishes the repetition rate of the modulation pulse, a circuit to delay the modulation pulse up to 300 microseconds after the start of the synchronizing pulse, and a circuit that permits the width of the output pulse to be adjusted from 0.5 to 10 microseconds in duration.

d. INTERNAL SAW-TOOTH GENERATOR. A gaseous discharge type sawtooth generator circuit is also incorporated in the signal generator to apply sawtooth modulation to the radio frequency oscillator to produce a frequency-modulated output pulse.

e. EXTERNAL SYNCHRONIZATION AND MODULATION. Provisions are made for employing external synchronizing pulses as well as external modulating voltages when desired.

1-12. TRANSIT CASE CY-1294/U. (See figure 1-2.)

1-13. Transit Case CY-1294/U consists of a case and a removable cover. The cover is provided with a double lip that is filled with sponge rubber, providing a watertight seal when the case is closed. Heavy sponge rubber shockmounts protect the signal generator when it is in the case (figure 1-3) and ample space is provided in the transit case for storing the accessory cables and cords under the generator.

1-14. ACCESSORIES.

1-15. CABLES AND CORDS. The cables and cords supplied with the equipment are shown in figure 1-1. These are:

a. RF cable CG-92D/U(6'0"). This cable is used to couple the super-high frequency output of the signal generator to the external load. It consists of six feet of RG-9A/U coaxial cable terminated at each end with a UG-21D/U connector.

b. Two video Cords CG-409/U(8'0"). These cords are used for connecting synchronizing and modulating pulses to the BNC connector on the front panel of the signal generator. Each cord consists of eight feet of RG-58/U cable terminated at each end with UG-88/U connectors.

c. Power Cable CX-337/U(6'0"). This cable applies the 115-volt primary power to the signal generator.

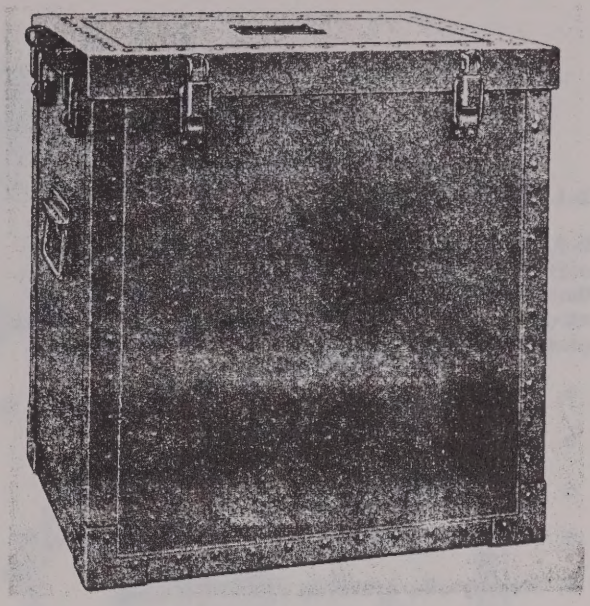


Figure 1-2. Transit Case CY-1294/U

It consists of six feet of two-conductor cable with a two-prong male connector on one end and a two-contact female connector on the other.

1-16. OTHER ACCESSORIES. Other accessories supplied are:

a. Two spare klystron grid contact springs for use when replacement of the klystron becomes necessary. These are carried in the transit case.

b. Four Allen wrenches for use when maintenance of the equipment becomes necessary. These are stowed within the instrument and are shown in figure 4-5.

c. One hexagonal socket wrench for use when removal of the klystron becomes necessary. This wrench is also stowed within the instrument and is shown in figure 4-5.

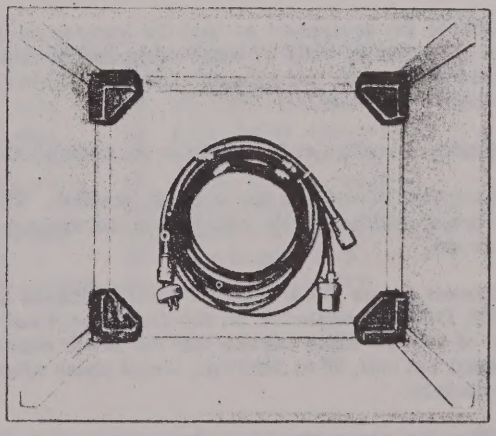


Figure 1-3. Location of Accessories in Bottom of Transit Case CY-1294/U

SECTION II

OPERATING PROCEDURES

2-1. SCOPE OF PROCEDURES.

2-2. The following items, which are individually described more completely in later paragraphs, must be thoroughly studied in the order given and fully understood in order to derive maximum use of the signal generator. These items are:

a. Unpacking the equipment

b. Preparing for use

c. Description of operating controls

d. Calibrating the output level of the signal generator

e. Step-by-step operating procedure

f. Turning off the equipment

2-3. SEQUENCE OF PROCEDURE.

2-4. UNPACKING THE EQUIPMENT. The lid of the equipment's Transit Case, CY-1294/U, is held in place by means of eight trunk latches. After removing the lid, place the transit case on the floor or a low table to facilitate removal of the instrument, which rests freely on rubber mounts on the bottom of the transit case. The accessory cables and cords are stored on the bottom of the transit case under the signal generator. Check to see that all items shown in figure 1-1 are present.

2-5. PREPARING FOR USE. All controls and indicators referred to in the following steps are the same as those called out in figure 2-1. If the indications described in the steps below are not obtained, the equipment should be turned over to maintenance personnel to locate and correct the trouble before proceeding further. Proceed as follows:

a. Locate the equipment so that the louvres on the cabinet are clear of walls or other equipment in order to secure free intake and exhaust of air by the blower unit within the cabinet.

b. Remove the cables and cords from the transit case.

c. Place the ON switch in its down, off, position. This is the normal position of this switch when the equipment is not in use.

d. Connect Power Cable CX-377/U(6'0") between the POWER INPUT connector on the front panel and a source of power. Make certain that the power source is nominal 115 volt, 50 to 1000 cps, single phase alternating current.

e. When the connection from the instrument to the required power source has been completed, the HEATER indicator, located to the left of the ON switch on the front panel, will light, indicating that electrical power is being supplied to the POWER INPUT connector of the signal generator.

f. Turn the ON switch to the up, or ON, position. With the switch in this position, the HEATER indicator will go off, and the POWER indicator, located to the right of the HEATER indicator, will now light, and the sound of the blower motor will be heard. With the ON switch in the ON position and the MOD. SELECTOR switch (13) in the CW position, the needle of the POWER SET meter (8) will begin to move after approximately 30 seconds have elapsed. After approximately two minutes a delay relay will operate and the r-f oscillator will be put into operation.

g. Connect RF Cable CG-92D/U(6'0") to the RF OUTPUT connector.

h. Turn on any auxiliary equipment with which the signal generator is to be used and allow it to warm up.

2-6. DESCRIPTION OF OPERATING CONTROLS. (See figure 2-1.) The operating controls of Signal Generator TS-621/U are illustrated in figure 2-1. In each of the following descriptions, the number in parentheses after the name of the control corresponds to the number of the call out of the control in figure 2-1. Switch positions are not referenced by number. All the controls are located on the front panel. A description of their functions follows:

a. ON switch (1). When this switch is in the up, or ON position, power is applied to the electronic circuits of the signal generator. When it is in the downward position, power is applied to the space heaters in the cabinet that are employed to de-humidify the interior of the signal generator when the signal generator is not in use.

b. POWER indicator (2). When this indicator is on, HEATER indicator (3) will be off. This indicates that power is applied to the electronic circuits of the signal generator, and removed from the space heaters.

c. HEATER indicator (3). When this indicator is on, POWER indicator (2) will be off. This indicates that power is applied to the space heaters and removed from the electronic circuits.

d. SIGNAL FREQUENCY control (4). This control is used to adjust the klystron oscillator to the desired frequency. This frequency is indicated on the MEGACYCLES dial (5) above the control. A continuously rotatable vernier scale graduated from 0 to 100 is provided on the control itself so that accurate resetting to a specific frequency can be made.

e. ZERO SET control (6). This control is used to adjust the needle of the POWER SET meter (8) to the zero position when the MOD. SELECTOR switch (13) (upper left hand corner of the panel) is in the OFF position.

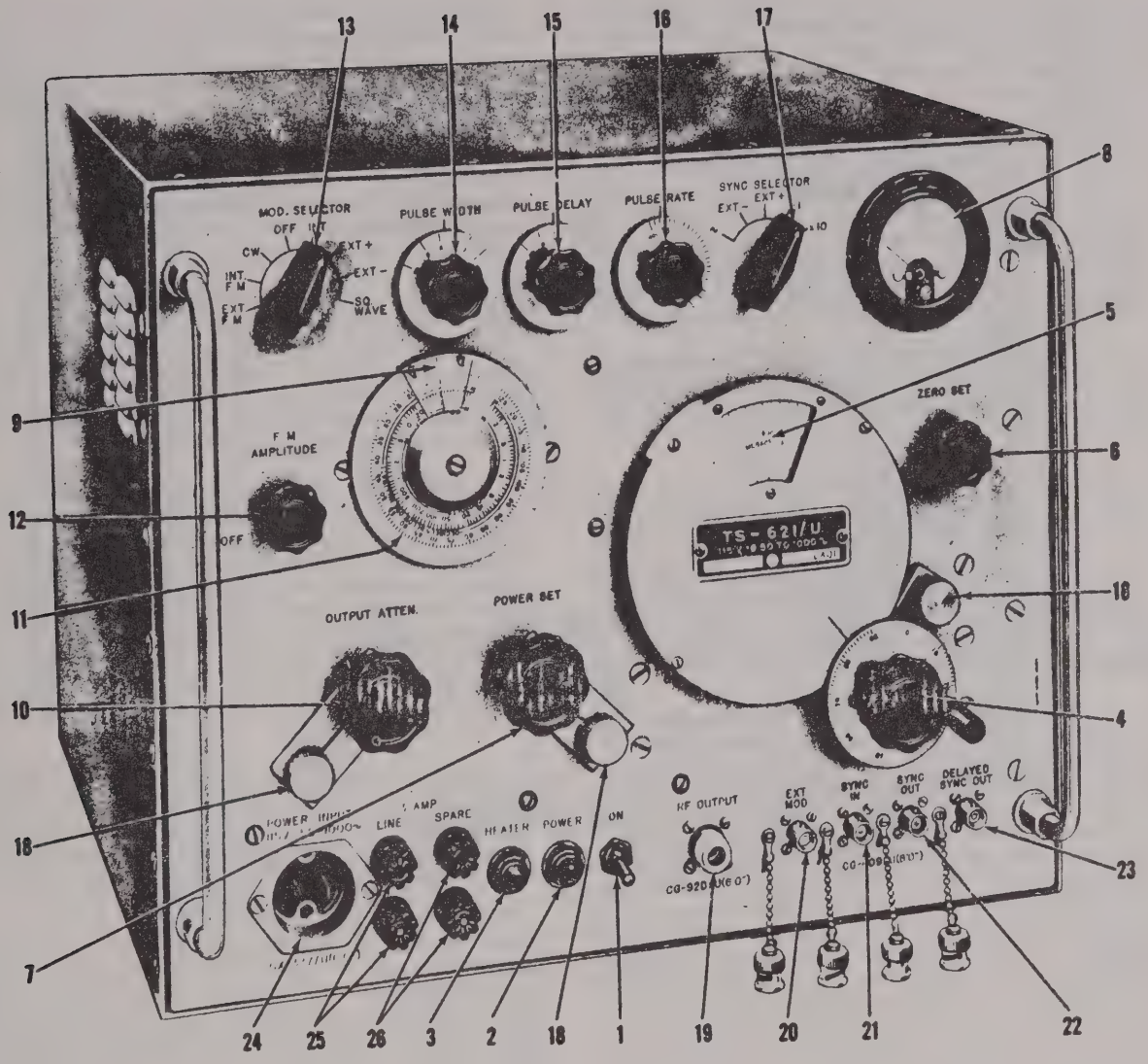


Figure 2-1. Signal Generator AN/URM-52, Operating Controls and Connections

1. ON switch
2. POWER indicator
3. HEATER indicator
4. SIGNAL FREQUENCY control
5. MEGACYCLES dial
6. ZERO SET control
7. POWER SET control
8. POWER SET meter
9. Attenuator dial index
10. OUTPUT ATTEN. dial
11. OUTPUT ATTEN. dial
12. FM AMPLITUDE control
13. MOD. SELECTOR switch
14. PULSE WIDTH
15. PULSE DELAY control
16. PULSE RATE control
17. SYNC. SELECTOR switch
18. Control locks
19. RF OUTPUT connector
20. EXT. MOD. connector
21. SYNC. IN connector
22. SYNC. OUT connector
23. DELAYED SYNC. OUT connector
24. POWER INPUT connector
25. Line fuseholders
26. Spare fuseholders

f. POWER SET control (7). With the MOD. SELECTOR switch (17) in CW position, this control is used to adjust the needle of the POWER SET meter (8) to 0 dbm (red line at center of scale) prior to adjusting the attenuation. It also operates the transparent index window (9) over the OUTPUT ATTEN. (attenuator) dial (11) to establish the reference level for reading the attenuator dial.

g. OUTPUT ATTEN. (attenuator) control (10). This control determines the radio frequency output level of the signal generator. It also operates the OUTPUT ATTEN. dial (11) so that the reading of this dial under the index line (9) indicates the output level of the signal generator in terms of decibels below one milliwatt.

h. FM AMPLITUDE control (12). This control adjusts the deviation (frequency swing) of the output frequency from the center (CW) frequency when frequency modulation is employed.

i. MOD. SELECTOR switch (13). This switch is located in the upper left hand corner of the front panel of the signal generator. It has the following positions:

1. EXT. FM. When the switch is in this position, the signal generator circuits are connected so that an external sine or sawtooth voltage may be applied to the EXT. MOD. input connector (20) to provide frequency modulated output.

2. INT. FM. When the switch is in this position, the signal generator circuits are connected so that frequency modulated r-f voltage is provided at the output. When the SYNC. SELECTOR switch (17) is in the XI or X10 position, these pulses are initiated by the internal pulse generating circuits of the signal generator, and the recurrence rate of frequency deviation is indicated by the PULSE RATE control (16) multiplied by the setting of the SYNC. SELECTOR switch (17), X1 or X10. At the start of each recurring frequency variation, a synchronizing pulse is provided at SYNC. OUT connector (22). The degree of frequency swing is determined by the FM amplitude control (7).

3. CW. When the switch is in this position, the output of the signal generator is a continuous wave of radio frequency voltage.

4. OFF. When the switch is in the OFF position, the r-f oscillator is biased off so that the signal generator will provide no r-f output. This position is provided to permit the POWER SET meter (8) to be zero set before each test by adjustment of the ZERO SET control (6) (see paragraph 2-13). However, filament and rectifier voltages will be applied to all tubes so that the signal generator may be instantly operative when this switch is moved to one of its other positions.

5. INT. When the MOD. SELECTOR switch is in this position, the pulse repetition frequency is determined by the internal synchronizing circuits of the signal generator, and is indicated by the position of the PULSE RATE control (16) when the SYNC. SELECTOR switch (17) is in the X1 position. When the latter control is in the X10 position, the pulse rate will be 10 times the rate indicated by the PULSE RATE control (16). When the MOD. SELECTOR switch (13) is in the INT. position and the SYNC. SELECTOR switch (17) is in one of the three most counterclockwise positions, the internal pulse generating circuits may be synchronized from an external source of voltage. Refer to item "m" below for a complete description of operation of the SYNC. SELECTOR switch (17).

6. EXT.+. When the MOD. SELECTOR switch is in this position, the signal generator may be modulated by positive external pulses of voltage applied to the EXT. MOD. connector (20) on the front panel.

7. EXT.-. When the MOD. SELECTOR switch is in this position, the signal generator may be modulated by negative pulses applied to the EXT. MOD. connector (20) on the front panel. Refer to paragraph 1-9 c(1) for permissible range of characteristics of both positive and negative pulses employed for externally modulating the r-f output of the signal generator.

8. SQ. WAVE. When the switch is in the SQ. WAVE position, the output of the signal generator will be rectangular pulses closely approaching a square wave at 1,000 cycles. The repetition rate of these pulses is determined by the PULSE RATE control (16) and by the setting of the SYNC. SELECTOR switch (17) (X1 or X10 position) over the range of 40 to 4,000 pulses per second. The "on" time will be approximately equal to the "off" time. At the start of each cycle of square wave, a synchronizing pulse is provided at the SYNC. OUT connector (22).

j. PULSE WIDTH control (14). The adjustment of this calibrated control determines the time duration of the pulse of radio frequency voltage when the MOD. SELECTOR switch (13) is in the INT. position. The time duration is adjustable from 0.5 to 10 microseconds.

k. PULSE DELAY control (15). This control determines the time delay between the start of the synchronizing pulse and the start of the radio frequency output pulse, regardless of the type of synchronization employed. The control permits the insertion of delays from 3 to 300 microseconds following the synchronizing pulse. This same delay will be present between the pulses appearing on the SYNC. OUT connector (22) and the DELAYED SYNC. OUT connector (23) on the control panel. The output from either connector may be employed for synchronizing external equipment.

l. PULSE RATE control (16). The setting of this control determines the pulse repetition frequency of the internal pulse generating circuits when the MOD. SELECTOR switch (13) is in the INT., INT. FM or SQ. WAVE position and the SYNC. SELECTOR switch (17) is in either the X1 or the X10 position. When the SYNC. SELECTOR switch is in the X1 position, the pulse repetition rate is indicated directly on the calibrated dial of the control. When the SYNC. SELECTOR switch is in the X10 position, the reading of the calibrated dial of the control must be multiplied by 10 to indicate pulse repetition rate.

m. SYNC. SELECTOR switch (17). This switch determines the type of synchronization that is to be employed when the MOD. SELECTOR switch (13) is in the INT. position, thus placing the internal pulse modulation

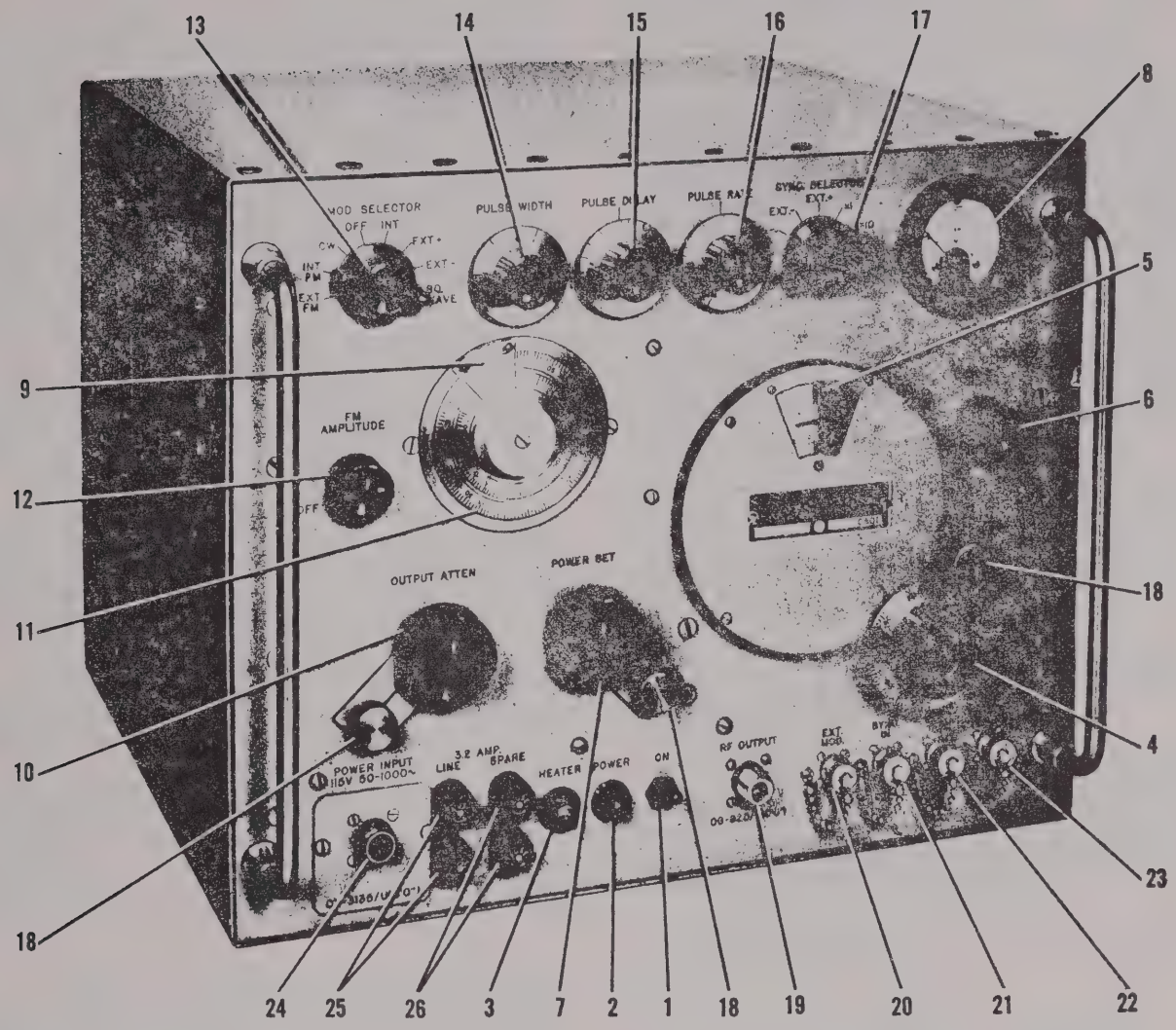


Figure 2-1A. Signal Generator AN/URM-52A, Operating Controls and Connections

1. ON switch
2. POWER indicator
3. HEATER indicator
4. SIGNAL FREQUENCY control
5. MEGACYCLES dial
6. ZERO SET control
7. POWER SET control
8. POWER SET meter
9. Attenuator dial index
10. OUTPUT ATTEN. dial
11. OUTPUT ATTEN. dial
12. FM AMPLITUDE control
13. MOD. SELECTOR switch
14. PULSE WIDTH
15. PULSE DELAY control
16. PULSE RATE control
17. SYNC. SELECTOR switch
18. Control locks
19. RF OUTPUT connector
20. EXT. MOD. connector
21. SYNC. IN connector
22. SYNC. OUT connector
23. DELAYED SYNC. OUT connector
24. POWER INPUT connector
25. Line fuseholders
26. Spare fuseholders

circuits in operation. The SYNC. SELECTOR switch has the following positions.

1. When the switch is in the sine wave, or extreme counterclockwise position, and the MOD. SELECTOR switch (13) is in the INT. position, the signal generator may be synchronized by an external sine wave voltages with an amplitude between 5 and 50 volts rms, applied through the SYNC. IN connector (21) on the front panel.

2. EXT.-. When the switch is in this position and the MOD. SELECTOR switch (13) is in the INT. position, the signal generator may be synchronized by external negative pulses of an amplitude between 5 and 50 volts peak, applied through the SYNC. IN connector (21) on the front panel.

3. EXT.+. When the SYNC. SELECTOR switch is in this position and the MOD. SELECTOR switch (13) is in the INT. position, the signal generator may be synchronized by external positive pulses with an amplitude between 5 and 50 volts, applied through the SYNC. IN connector (21) on the front panel.

4. X1. When the switch is in this position and the MOD. SELECTOR switch (13) is in the INT. position, synchronization is by the internal time base circuit. The repetition rate of the r-f output pulses is indicated directly by the PULSE RATE control (16).

5. X10. When the switch is in this position and MOD. SELECTOR switch (13) is in the INT. position, the repetition rate of the r-f output pulses is ten times the rate indicated by the PULSE RATE control (16).

2-7. CALIBRATING THE OUTPUT LEVEL OF THE SIGNAL GENERATOR. Paragraphs 2-8 through 2-13 describe the settings of the controls for securing various types of output from the signal generator. Calibration of the output level of the signal generator for any frequency and for all conditions of operation (paragraphs 2-10 through 2-12) is as follows:

a. With the equipment connected to a nominal 115 volt, 50 to 1000 cps, single phase power source, and with the ON switch in the up, or ON, position, as described in paragraph 2-5, steps c through h, allow the instrument to heat for a minimum of 5 minutes with the MOD. SELECTOR switch in CW position. If the ambient temperature is below about 10°C (50°F), a longer warm-up period is desirable.

b. By means of SIGNAL FREQUENCY control (4) tune signal generator to desired frequency as indicated on MEGACYCLES dial (5).

c. Turn MOD. SELECTOR switch (13) to OFF. Adjust ZERO SET control (6) so that needle of POWER SET meter (8) is exactly over ZERO SET index line.

d. Place MOD. SELECTOR switch (13) to CW. Adjust POWER SET control (7) so that needle of POWER SET meter (8) rests on red line at center of scale, 0 DBM.

e. Allow the equipment to stand for approximately 10 minutes with MOD. SELECTOR switch (13) on CW.

f. Repeat steps c and d following warm-up period. When needle of meter remains on 0 DBM with little or no deviation, signal generator has reached a stabilized temperature and is ready for use.

2-8. STEP-BY-STEP OPERATING PROCEDURE.

2-9. For the purpose of the following adjustments, the signal generator is assumed to be warmed up, calibrated for output reference level, and ready for operation on the desired frequency, as described in paragraph 2-7. External synchronizing and/or modulating equipment should be turned on and allowed to warm up. Operating the signal generator can be divided into two parts: (a) adjusting the r-f section, and (b) adjusting the modulator section. In general, it is desirable first to adjust the r-f section, since this adjustment establishes the reference levels for the output power-monitoring system. This adjustment is essentially the same as that required to obtain CW output. The following paragraphs outline the step-by-step procedures necessary in order to obtain the various types of outputs.

2-10. TO ADJUST THE R-F SECTION AND TO OBTAIN CW OUTPUT. (See figures 2-1 and 2-1A.) To adjust the r-f section and to obtain CW output from the signal generator, proceed as follows:

a. Turn MOD. SELECTOR switch (13) to CW.

b. Adjust OUTPUT ATTEN. control (10) to desired value of attenuation as indicated by OUTPUT ATTEN. dial (11) under index window (9).

c. The adjustments of SIGNAL FREQUENCY control (4) in accordance with paragraph 2-7, step b, and OUTPUT ATTEN. control (10) determine the frequency of the r-f output of the signal generator and the output power level in decibels below one milliwatt (dbm) (0.228 volt) when working into the rated load of 52 ohms.

d. The individual settings of other operating controls are of no importance.

NOTE

For a given setting of the OUTPUT ATTEN. dial (11), the indicated peak voltage of the r-f output under conditions other than CW will be within ± 1 decibel of that for CW operation.

e. If the radio frequency is changed it will be necessary at each new frequency to follow the calibration procedure given in steps d through f of paragraph 2-7 above if full accuracy of the OUTPUT ATTEN. dial (11) is desired. If full accuracy of the OUTPUT ATTEN. dial (11) is not required, it may not be necessary to recalibrate at frequencies close to the frequency of initial calibration.

f. Connect r-f cable between RF OUTPUT connector (19) on signal generator and load.

2-11. TO OBTAIN INTERNALLY MODULATED OUTPUT. Several types of output may be obtained under this condition, as described in paragraph 1-9b. The

adjustments necessary to obtain internally modulated output are as follows:

a. SQ. WAVE OUTPUT. (See figure 2-1.) To obtain SQ. WAVE r-f output from the signal generator, proceed as follows:

1. Set MOD. SELECTOR switch (13) to SQ. WAVE.

2. Set SYNC. SELECTOR switch (17) to X1 or X10 position as necessary to obtain desired repetition rate.

3. Set PULSE RATE control (16) to desired pulse repetition rate.

4. The PULSE WIDTH control (14) and the PULSE DELAY control (15) do not affect SQ. WAVE operation.

5. Connect r-f cable between RF OUTPUT connector (19) on signal generator and load.

6. A sync pulse is available at SYNC. OUT connector (22) for each cycle of square wave.

b. PULSED R-F OUTPUT, NO DELAY. (See figure 2-1.) For this type of operation, proceed as follows:

1. Set MOD. SELECTOR switch (13) to INT. See paragraph 2-6 i(5) for complete description of operation with MOD. SELECTOR switch (13) on INT.

2. Set SYNC. SELECTOR switch (17) to position for type of synchronization desired. See paragraph 2-6m for description of types of operation which may be chosen by means of SYNC. SELECTOR switch (17).

3. If internal synchronization is employed, set PULSE RATE control (16) to desired repetition rate, taking due account of the setting of SYNC. SELECTOR switch (17), X1 or X10 position.

4. If external synchronization is employed, connect to SYNC. IN connector (21), a synchronizing voltage source, of 5 to 50 volts amplitude, and of type and polarity indicated by SYNC. SELECTOR switch (17). When synchronized by external equipment, the signal generator provides at SYNC. OUT connector (22) a pulse which occurs simultaneously with the leading edge of the pulse applied to the SYNC. IN connector (21).

5. Set PULSE WIDTH control (14) to desired position between 0.5 and 10 microseconds.

6. Connect r-f cable between RF OUTPUT connector (19) on signal generator and load.

7. Connect a video cord between DELAYED SYNC. OUT connector (23) and outside equipment if a synchronizing pulse simultaneous with start of r-f pulse is desired.

c. PULSED R-F OUTPUT, DELAYED. (See figure 2-1.) For this type of operation, proceed as follows:

1. Adjust all controls to positions described in paragraph 2-11b, except PULSE DELAY control (15), which is set to position indicating desired delay, in microseconds, as read on the calibrated dial. This setting can be made to provide a delay from 3 to 300 microseconds after leading edge of SYNC. OUT pulse.

2. If external synchronization is employed, connect to SYNC. IN connector (21), a synchronizing voltage source, of proper type and polarity and of 5 to 50 volts amplitude. When synchronized by external equipment, the signal generator provides at SYNC. OUT connector (22) a pulse which occurs simultaneously with leading edge of pulse applied to SYNC. IN connector (21).

3. Attach one of the video cords between SYNC. OUT connector (22) and external equipment if desired.

4. Connect the remaining video cord between DELAYED SYNC. OUT connector (23) and external equipment to provide a synchronizing pulse occurring simultaneously with the start of the pulse of radio frequency energy.

5. Connect r-f cable between RF OUTPUT connector (19) and external load.

d. INTERNAL FREQUENCY MODULATION. It should be noted here that the characteristics of the klystron do not lend themselves to linear frequency deviation by a linear voltage excursion applied to the repeller. Therefore, the resulting frequency modulation is only an approximate representation of a sawtooth, and is accompanied by discernible amplitude modulation. For internal frequency modulation (sawtooth), proceed as follows:

1. Set MOD. SELECTOR switch (13) to INT. FM.

2. Set SYNC. SELECTOR switch (17) to X1 or X10 position as required to establish setting of PULSE RATE control (16).

3. Set PULSE RATE control (16) to desired position so that calibrated dial indicates pulse repetition frequency as read on PULSE RATE control multiplied by the position indicated on SYNC. SELECTOR switch (17), either the direct reading, or the reading multiplied by 10.

4. From the counterclockwise, OFF position, slowly turn the FM AMPLITUDE control (12) clockwise to the desired frequency deviation. Because of the characteristics of the klystron, the frequency deviation should be adjusted so it will not exceed the limits of operation of the klystron which would result in instability. If unstable operation should occur, return the FM AMPLITUDE control to the OFF position and slowly rotate clockwise to a point just short of where instability occurred.

5. Connect r-f cable between RF OUTPUT connector (19) on signal generator and load.

6. Connect video cable between SYNC. OUT connector (22) and external equipment, if desired.

2-12. TO OBTAIN EXTERNALLY MODULATED OUTPUT. Either pulse or frequency modulated output from

the signal generator may be obtained when modulated from an external source. The adjustments of the controls are described below.

a. EXTERNAL PULSE MODULATION. For external pulse modulation, proceed as follows:

1. Set MOD. SELECTOR switch (13) to EXT.+ or EXT.-, as required by the polarity of the external modulating pulse to be used.

2. Connect external modulation pulse voltage with an amplitude of at least 15 volts to EXT. MOD. connector (20) on the front panel. (See paragraph 1-9 c(1) for permissible range of characteristics of pulses to be employed.)

3. Other controls are inoperative and may remain in any position.

4. Connect r-f cable between RF OUTPUT connector (19) and load. No synchronizing pulses are available from the unit under these conditions.

b. EXTERNAL FREQUENCY MODULATION. For external frequency modulation, adjust the controls as follows:

1. Set MOD. SELECTOR switch (13) to EXT. FM position.

2. Connect external modulation voltage (important see paragraph 1-9 c(2) for types and values of voltages to be employed) to the EXT. MOD. connector (20) on the front panel.

3. From counterclockwise, OFF, position, slowly adjust FM AMPLITUDE control (12) clockwise for desired frequency excursion. Refer to paragraph 2-11 d(4) regarding unstable operation caused by excessive repeller voltage variation.

4. Connect r-f cable between RF OUTPUT connector (19) and load. No output synchronizing pulses are available from the unit under these conditions.

2-13. INSTRUMENT READINGS AND INDICATOR PRESENTATIONS. Indicator presentations are the conventional ones to be expected and are dependent upon the operation or use to which the equipment is being put for each instance. In normal operation, the POWER SET meter is used for calibration only, as described in paragraph 2-7.

2-14. TURNING OFF THE EQUIPMENT. Regardless of the positions of the other controls place ON switch in the down, off, position. This removes power from all electronic circuits and applies power to the space heaters. To completely remove power from the instrument, disconnect power cable.

SECTION III

OPERATING CHECKS AND ADJUSTMENTS

3-1. GENERAL.

3-2. Beyond the individual calibrations of the signal generator made prior to each measurement, described under paragraph 2-7, further operating checks and adjustments are required only during service of the equipment. Service of the signal generator is fully described in the Handbook of Service Instructions, AN 16-30URM52-2.

SECTION IV

EMERGENCY OPERATION AND REPAIR

4-1. GENERAL.

4-2. Signal Generators TS-621/U, TS-621A/U and TS-621B/U are calibration instruments designed for use in determining frequencies and power output levels of various types of super-high frequency equipment. When the signal generators fail to operate normally, their value as a standard is reduced for one or both of these functions. Under emergency conditions in which circumstances do not permit full utilization of normal channels for repair, the signal generators may be operated as described in this section, or, if necessary, fuses and tubes, except V-114, normally may be replaced by the operator. Because the signal generators are used in servicing or testing other equipment, the operating personnel will be qualified maintenance personnel. For this reason, emergency maintenance given in this section includes procedure for making voltage adjustments following replacement of certain tubes as well as replacement of V-114 and its voltage adjustments, and generally is of a more advanced character as compared with that for conventional type communications equipment.

4-3. EMERGENCY OPERATION.

4-4. SIGNAL GENERATOR FREQUENCY CALIBRATION INACCURATE. When the frequency calibration of the signal generator is known to be inaccurate, calibrate by an outside source and prepare deviation scale if necessary.

4-5. OUTPUT ATTENUATOR INACCURATE. When the output attenuator of the signal generator is known to be inaccurate, measure power output by an external instrument and if necessary prepare deviation scale.

4-6. INOPERATIVE IN ONE OR MORE TYPES OF OPERATION. Employ other type of operation, as close to desired type as possible. Various types of operation are described in paragraphs 2-8 through 2-12.

4-7. EMERGENCY REPAIR.

4-8. LOCATION OF TUBES, FUSES AND LAMPS. The location of the tubes is shown in figure 4-1. The location of the fuses in the equipment is shown in figures 2-1 and 2-1A. Spare fuses are located in fuseholders on the front panel so that the fuse found to be blown may be replaced by a fuse from a spare fuseholder adjacent to the blown fuse. The indicator lamps are #47, rated at 6 - 8 volts at 0.15 ampere, and can be replaced after removing the jewel from the lampholder.

4-9. CABINET REMOVAL. The fit between the cabinet and instrument is intentionally tight. Removing the cabinet is a two-man job. Place instrument, panel down, on a low surface (floor or low table) so that it rests on the guard-rail handles. Unscrew the four captive screws on back of the cabinet (now facing up until the threads are free of the instrument. The screws will not come out of the cabinet. Cabinet is now free to to be lifted off instrument.

4-10. TUBE COMPLEMENT. The following tubes are located in the signal generator and are shown in figure 4-1. The tubes without asterisks can be replaced by the same type tubes without affecting the performance of the equipment. The tubes followed by asterisks (e.g., V-103*) are critical circuit tubes and replacement requires simple adjustments prior to operation of the equipment. These adjustments are described in paragraphs 4-11 through 4-25. In those instances where the adjustments are beyond the scope of operating personnel, or require special equipment not usually available, the expected deviations are discussed so that the equipment may be most effectively used in an emergency.

4-11. REPLACING CRITICAL CIRCUIT TUBES IN PULSER.

4-12. REPLACING V-103. Replacing V-103 may lessen the accuracy of the PULSE RATE dial but will not otherwise affect the performance of the signal generator. It should be noted, however, that the calibration of the dial is only approximate and at some settings the error may be as high as 25 percent. The repetition rate of the SYNC. OUT pulse may be compared with the frequency of the output from a standard audio oscillator and a deviation table prepared if required.

TABLE 4-1. TUBE COMPLEMENT, SIGNAL GENERATORS TS-621/U, TS-621A/U AND TS621B/U

Tube	JAN Type Number		Function
	TS-621/U TS-621A/U	TS-621B/U	
V-101	12AT7	12AT7WA	SYNC. IN Amplifier and Inverter
V-102	5726	5726	Coupling Diode (1/2 tube not used)
V-103*	5814	5814	PULSE RATE Multivibrator
V-104	5814	5814	SYNC. OUT Pulse Shaping Multivibrator
V-105	5814	5814	Pulse Amp. and SYNC. OUT Cathode Follower
V-106	5726	5726	Base Limiter and Clamp for Delay Multivibrator
V-107*	5814	5814	PULSE DELAY Multivibrator
V-108	5726	5726	Clamp and Negative Pulse Clipper

*See paragraph 4-10 text for replacement data.

TABLE 4-1. (Cont)

Tube	JAN Type Number		Function
	TS-621/U TS-621A/U	TS-621B/U	
V-109	5814	5814	Pulse Amp. - Inverter and DELAYED SYNC. OUT Cathode Follower
V-110	2D21	2D21	Thyratron Pulse Shaper
V-111*	5814	5814	PULSE WIDTH Multivibrator
V-112*	12AT7	12AT7WA	Clipper and Klystron Grid Clamp
V-113*	5763	5763	Modulator
V-114*	6236	6236	Radio Frequency Oscillator
V-115	5814	5814	DELAYED SYNC. OUT Pulse Shaping Multivibrator
V-301	5R4WGY	5R4WGB	Full Wave Rectifier
V-302*	6AU6	6AU6WA	Regulator Amplifier
V-303*	6AS7	6080WA	Series Regulator
V-304*	OA2	OA2WA	Voltage Regulator
V-305	5R4WGY	5R4WGB	Full Wave Rectifier
V-306*	6AU6	6AU6WA	Regulator Amplifier
V-307	5R4WGY	5R4WGB	Full Wave Rectifier
V-308*	6AS7	6080WA	Series Regulator
V-309*	6AU6	6AU6WA	Regulator Amplifier
V-310*	OA2	OA2WA	Voltage Regulator
V-311*	OA2	OA2WA	Voltage Regulator
V-312*	OA3	OA3	Voltage Regulator
V-313*	OA2	OA2WA	Voltage Regulator
V-314*	OA2	OA2WA	Voltage Regulator

*See paragraph 4-10 text for replacement data.

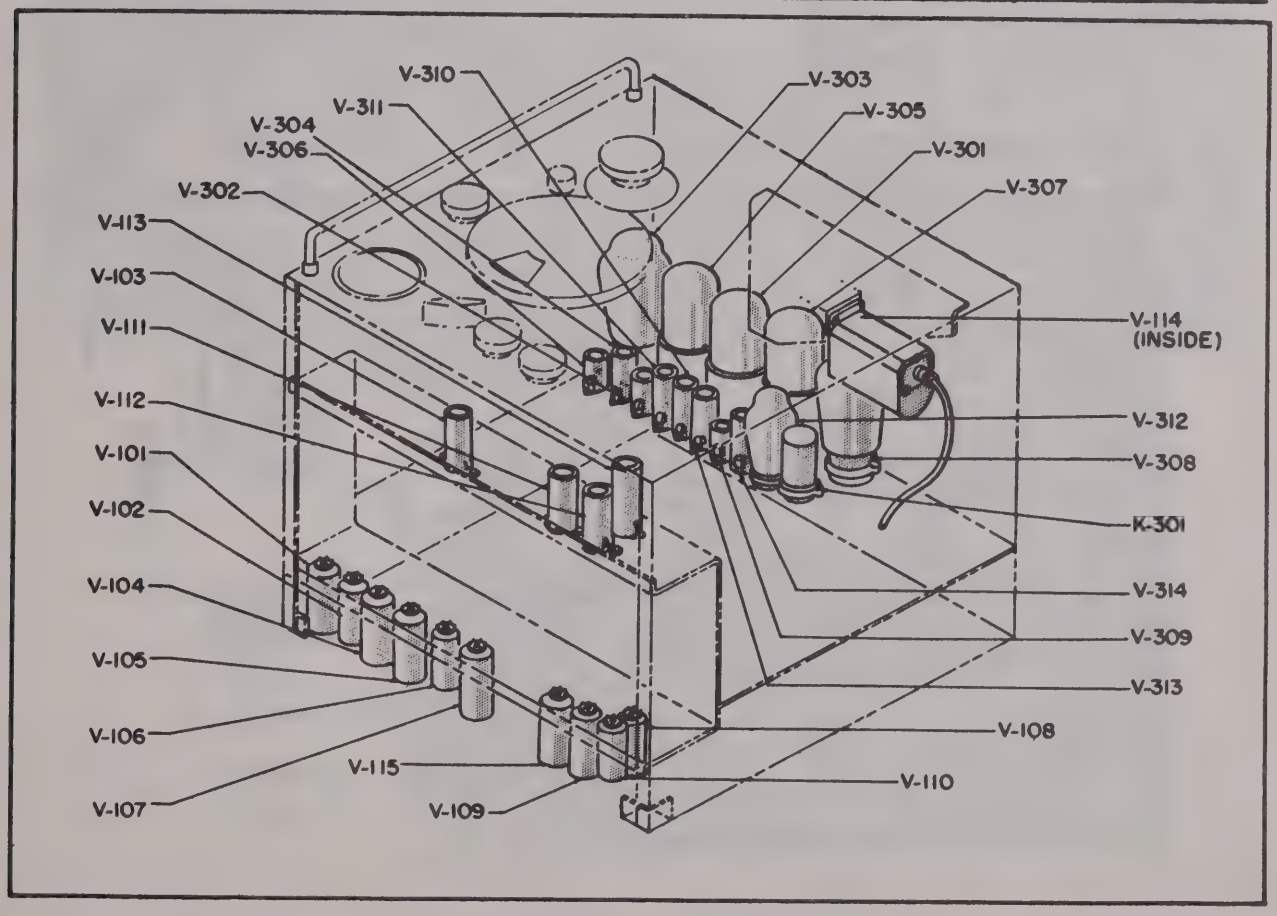


Figure 4-1. Location of Tubes

4-13. REPLACING V-107. Replacing V-107 may cause the calibration of the PULSE DELAY control to become inaccurate, and it may not be possible to obtain a maximum delay of 300 microseconds. However, the calibration of the PULSE DELAY dial is intended to be only approximate. With these limitations in mind, the operator may consider that the signal generator will otherwise be in operative condition for emergency use.

4-14. REPLACING V-111. Replacing V-111 may lessen the accuracy of the PULSE WIDTH control, and it may not be possible to reach either the maximum or minimum pulse widths indicated on the dial. If suitable equipment is available the pulse may be measured at pin 1 of V-111 on a calibrated oscilloscope and a deviation table prepared for emergency use.

4-15. REPLACING V-112 or V-113. When either V-112 or V-113 is replaced it is necessary to check and/or adjust the klystron control grid cutoff voltage and beam current as soon as the instrument is turned on. This is done as follows:

a. Place MOD. SELECTOR switch in OFF position.

b. Connect a voltmeter with a sensitivity not less than 1000 ohms-per-volt between pin 3 of V-303 and the chassis, with the positive lead of the voltmeter on the chassis.

c. Adjust R-338 (figure 4-2 and figure 4-2A) until the voltage is minimum (approximately 0.1 volt).

d. Place MOD. SELECTOR switch in CW position.

e. Adjust R-341 (figure 4-2 and figure 4-2A) until the voltage is exactly two volts, indicating a klystron beam current of 20 milliamperes. This value may be varied between 1.8 and 2.2 volts to give best operation of the klystron throughout the radio frequency range when pulse modulated.

4-16. REMOVING V-114.

NOTE

Except under an emergency, operating personnel should not attempt replacement of V-114. The procedure described in paragraphs 4-16 through 4-19 is included for use only as a last resort.

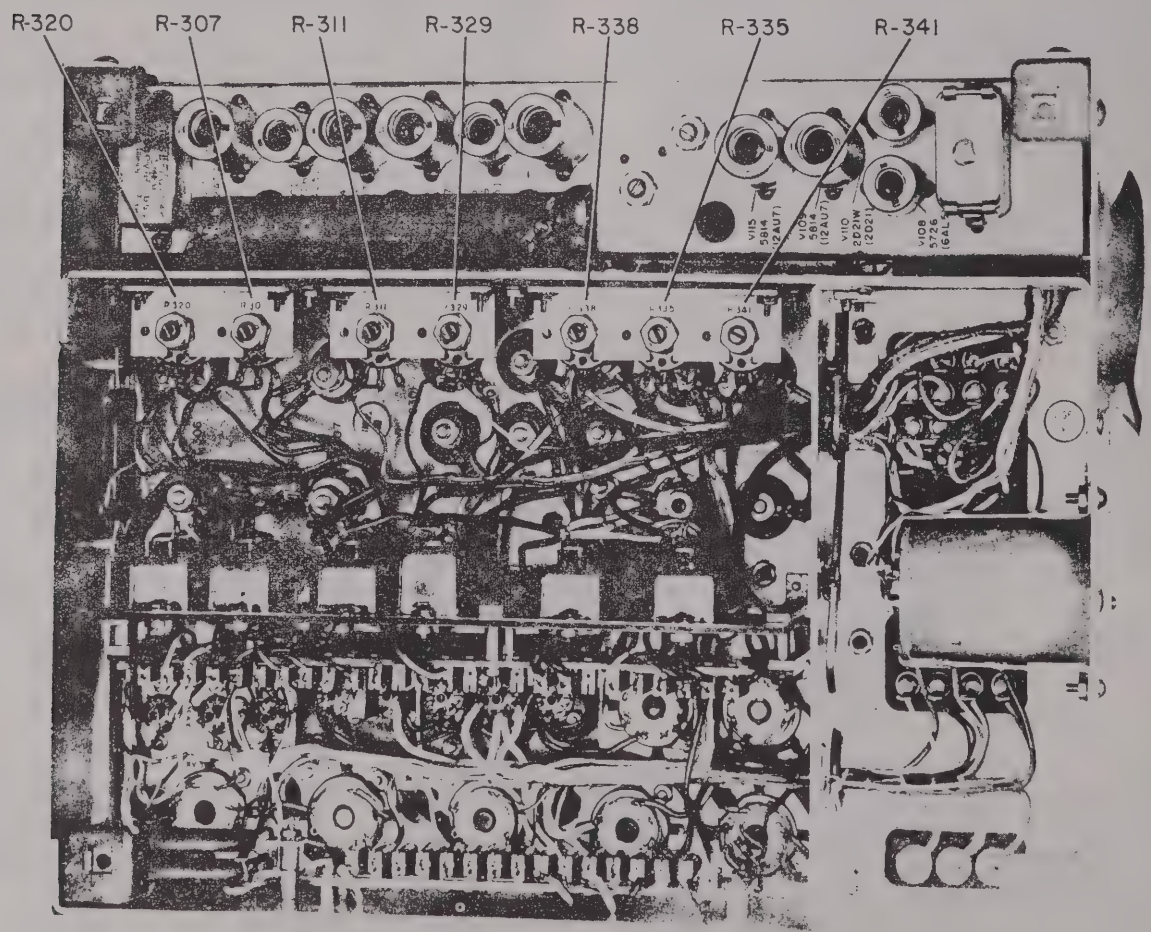


Figure 4-2. Location of Internal Controls, AN/URM-52 Power Supply

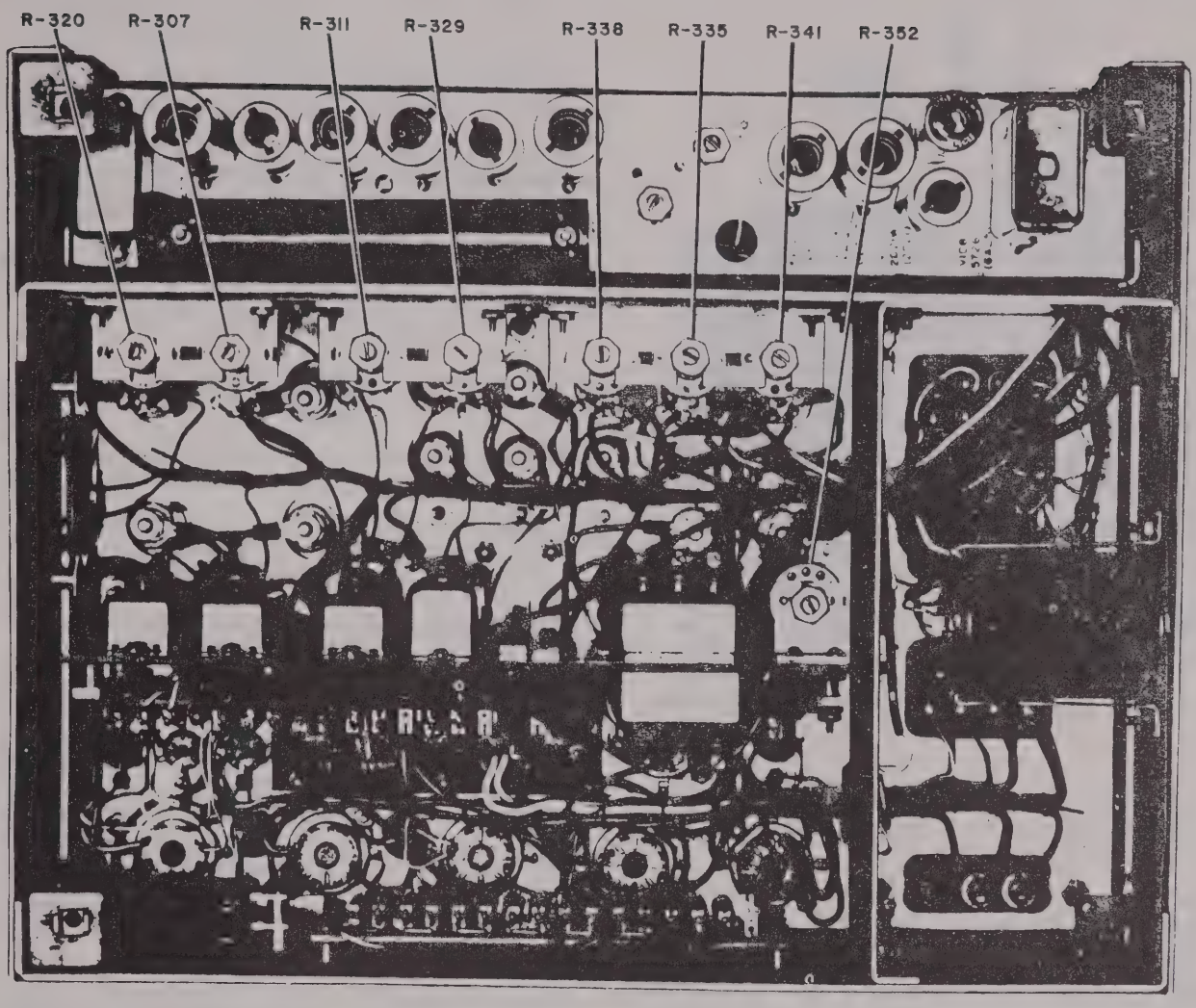


Figure 4-2A. Location of Internal Controls, AN/URM-52A Power Supply

The klystron oscillator tube is changed in accordance with the following procedure:

a. Place signal generator, with cabinet removed, in the position shown in figure 4-3 for ease in reaching tube.

b. Remove socket housing cap screws and lock washers (items 1 and 2, figure 4-4) with Allen wrench located in Fahnstock storage clip (figure 4-5) in back of chassis. Pull housing (item 3, figure 4-4) back until tube socket is exposed.

c. Pull straight back on socket until it is free of tube base.

CAUTION

Be very careful not to apply lateral pressure when removing the socket.

d. Unscrew the sleeve (4) that covers the body of klystron tube and remove it. Be careful not to push the klystron sideways in the cavity.

e. Turn tube (6) clockwise and pull straight back, removing it from cavity. Do not attempt to rock the tube or move it sideways. To do so may break the glass seals of the tube.

f. Remove semi-circular sections of clamping ring (5).

g. Unscrew hex nut (7) at entrance to cavity, using socket wrench stowed beside tubes on pulser deck (figure 4-5). Remove spring (8) below hex nut. Do not re-use this same spring except in an emergency. New springs are supplied with the equipment for tube replacement and are located in the plastic envelopes inside the transit case.

h. If the cavity ventilating pipe connector (11) protrudes within the cavity, remove connector nut (9) and disengage ventilating pipe (10). Loosen set nut (12) and back out the connector until flush with inside face of cavity plate. Tighten set nut (12).

4-17. INSTALLING NEW V-114. (See figure 4-4.) Procedure for installing the klystron, V-114, is given in the steps below. Prior to installing a new klystron, personnel should practice by reinstalling the old klystron. The proper force and twist required to push the klystron past the spring (8) may then be learned by practice.

CAUTION

When inserting the tube, always keep it straight in line with the cavity. Never work it from side to side. To do so will cause possible damage to the glass seals of the tube.

a. Install new spring (8) in entrance to the cavity so that the ends just meet and form a complete circle.

b. Thread hex nut (7) into cavity until it is seated very lightly against the spring. Press spring (8) back under nut (7) all around so that spring forms a perfect circle. Tighten nut slightly to hold spring in this position.

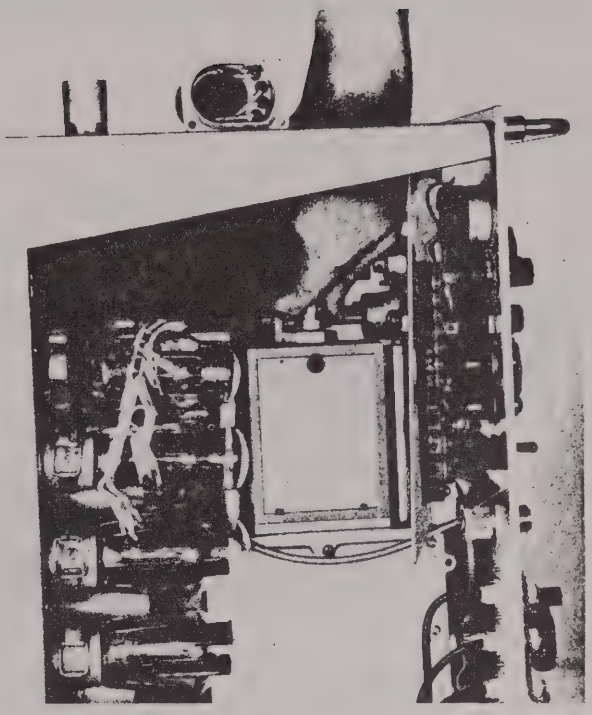


Figure 4-3. Signal Generator TS-621/U in Position for Klystron Replacement

c. Observing the caution noted above, insert klystron tube (6) into cavity and push it forward until it engages spring. Firmly press tube straight into cavity while at the same time giving it a clockwise twist. This will cause tube to compress spring slightly and to slide by spring and seat firmly against the cavity. Practice, as recommended, with the old klystron tube will enable the operator to feel when the tube is properly installed.

d. Tighten hex nut (7) moderately with the socket wrench supplied.

e. Insert split clamping ring (5), making certain that the sections of the ring encircle the grid ring of the klystron which can be seen just inside the hex nut. When ring is in proper position, three or four threads should be visible between clamping ring and outside face of nut.

f. Thread cover sleeve (4) into hex nut (7) so that it seats against clamping ring (5), causing it to grip klystron grid ring. Tighten firmly by hand.

g. Install the tube socket, pressing it straight onto the tube.

h. Position socket housing (3) and attach with the four cap screws (1) and washers (2) originally removed and tighten with long Allen wrench. Replace Allen wrenches in Fahenstock storage clips, and fasten socket wrench in place on pulser deck (figure 4-5).

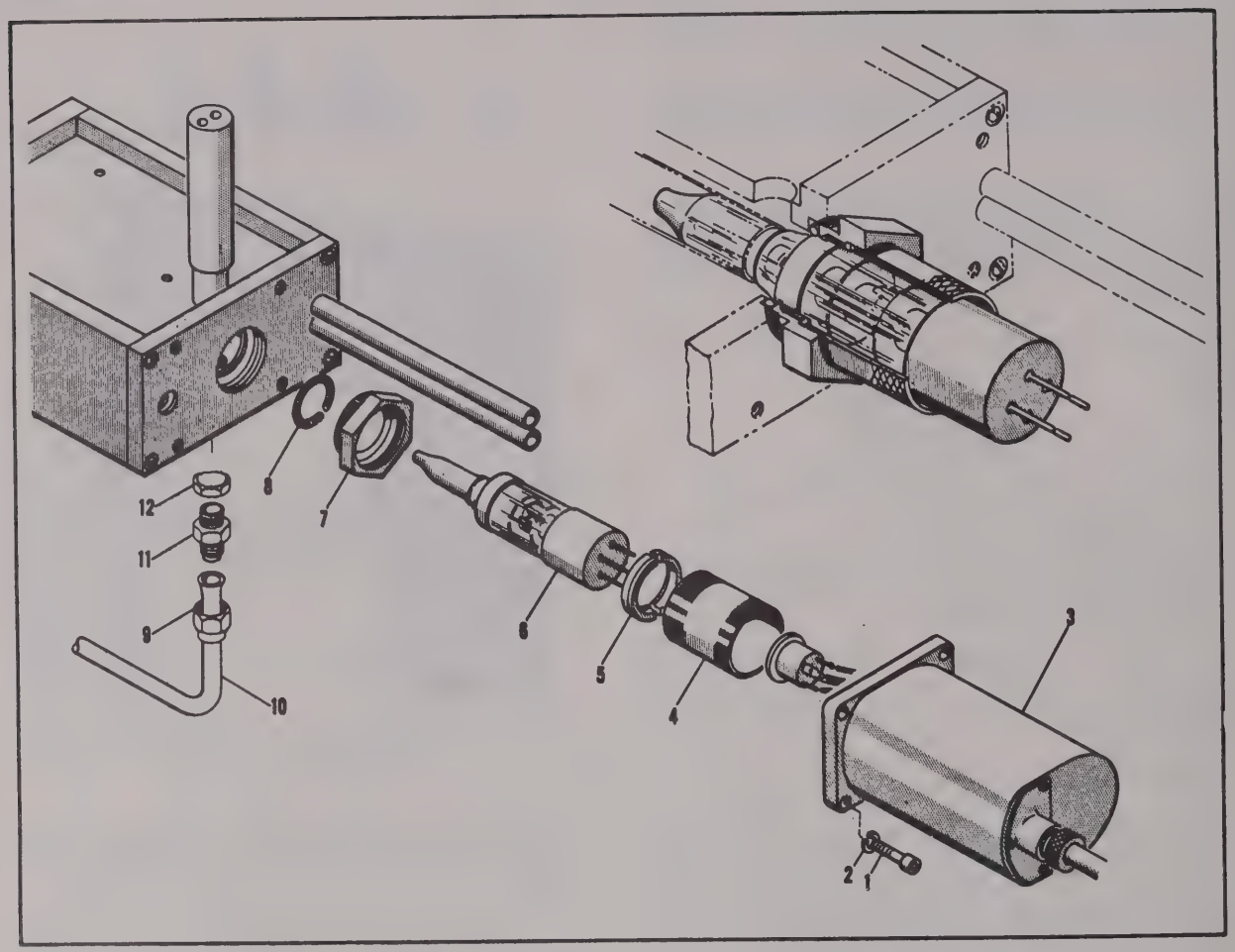


Figure 4-4. Klystron Assembly, Exploded View

1. Cap screw
2. Lock washer
3. Socket housing
4. Sleeve
5. Clamping ring
6. Klystron tube, V114
7. Hex nut
8. Spring
9. Connector Nut
10. Ventilating pipe
11. Ventilating pipe connector
12. Set nut

4-18. ADJUSTMENTS FOLLOWING REPLACEMENT OF V-114. Following replacement of V-114 it is important that certain adjustments be made as soon as the instrument is turned on. The following procedure is recommended:

a. With MOD. SELECTOR switch on OFF, turn on signal generator with new V-114 installed.

b. Check the voltage of the -1000-volt supply as described in paragraph 4-23.

c. Check the voltage of the -300-volt supply as described in paragraph 4-22.

d. With MOD. SELECTOR switch on CW, adjust the klystron beam current to 20 milliamperes as described in paragraph 4-15.

e. With MOD. SELECTOR switch on OFF, adjust the klystron cutoff bias as described in paragraph 4-15.

NOTE

The following three adjustments track the repeller voltage with the frequency drive mechanism. In general, this is done by observing square wave or pulsed output throughout the r-f range and making adjustments to give most dependable output.

f. With MOD. SELECTOR switch on CW, tune signal generator to 7400 megacycles.

g. Adjust R-170 (on frequency drive casting, figure 4-6) for peak power output as observed on POWER SET meter.

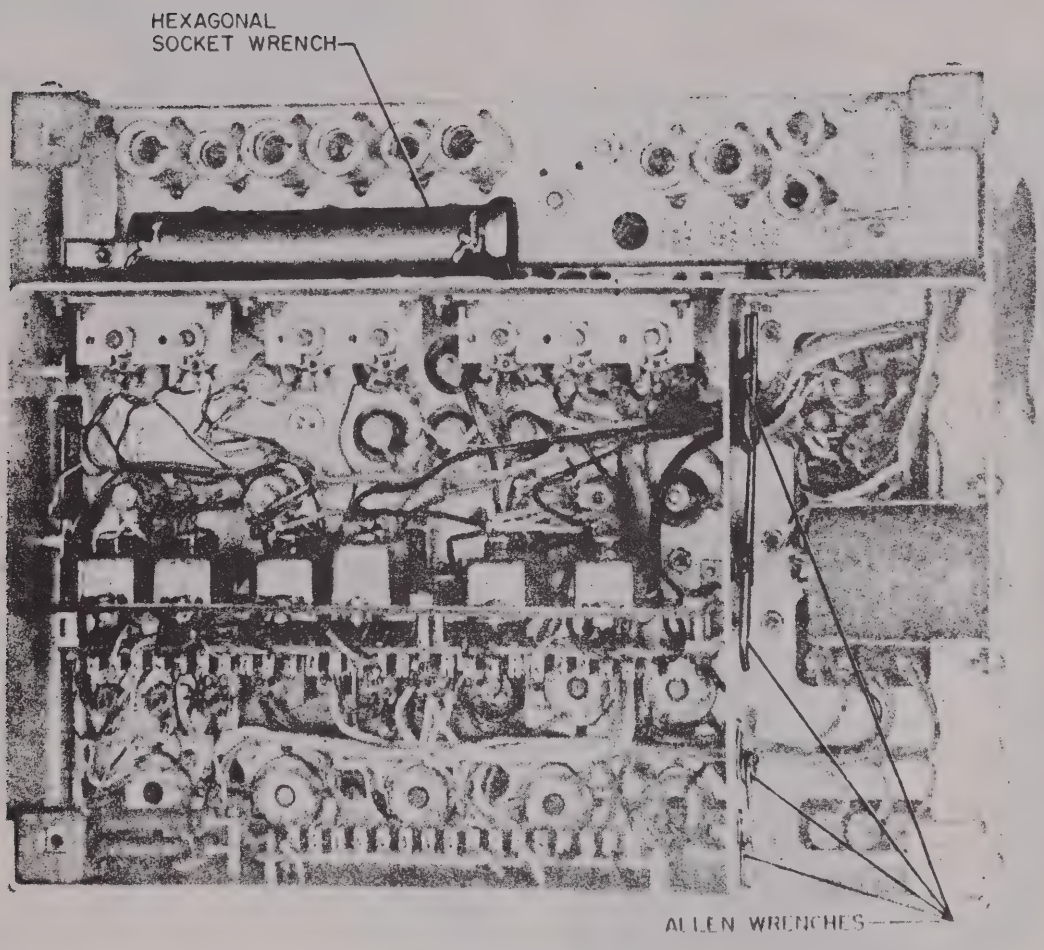


Figure 4-5. Location of Special Tools

h. Reduce peak power output one db by readjusting R-170. This reduction should be made by turning R-170 in the direction in which the power output decreases most slowly.

i. Tune signal generator to 4400 megacycles.

j. Adjust R-173 and/or R-178 (figure 4-6) for the indication described in steps g and h above.

k. Tune signal generator to 3800 megacycles.

l. Adjust R-175 (figure 4-6) for the indication described in steps g and h above.

m. Repeat the adjustments described above, as there is some degree of inter-action, particularly between the 4400 and 3800 megacycle adjustments.

n. Observe square wave operation throughout the entire r-f range. Should any weak or unstable points be noticed, slightly readjust repeller voltage for best operation. If operation is not improved, readjust klystron beam current as described in paragraph 4-15.

4-19. USE FOLLOWING REPLACEMENT OF V-114. The signal generator will be operative following replacement of V-114 as described in paragraphs 4-16, 4-17, and 4-18. However, the accuracy of the MEGACYCLES dial may be lessened. Complete and accurate recalibration of the signal generator is described in the Handbook of Service, AN/URM-52 and should be performed as soon as possible after the replacement of V-114 as described herein. For emergency use of the signal generator prior to recalibration, performance should be normal for use where exact calibration is not required. If external calibration equipment is available a deviation chart can be prepared in the area in which exact calibration is desired and the correction factor applied during emergency use.

4-20. REPLACING CRITICAL TUBES IN POWER SUPPLY.

4-21. GENERAL. In general, poor or unstable performance in all positions of the MOD. SELECTOR switch can be traced to the power supply. If possible, check tubes and replace any which appear doubtful.

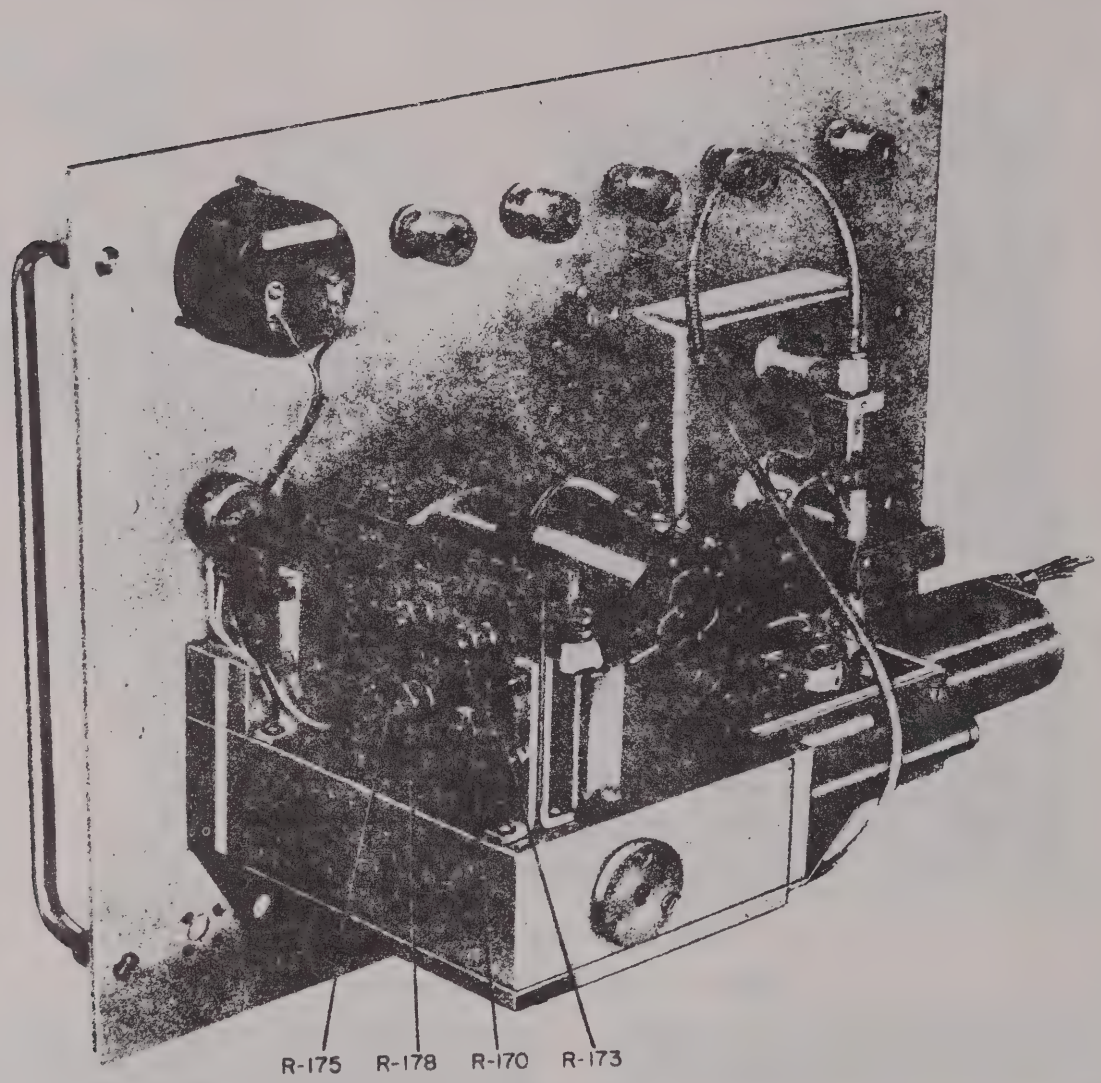


Figure 4-6. Location of Repeller Voltage Controls

4-22. REPLACING V-302, V-303, or V-304. Following replacement of V-302, V-303, or V-304:

a. Connect a d-c voltmeter with a sensitivity not less than 1000 ohms-per-volt across the terminals of capacitor C-304, with the positive lead of the voltmeter on the grounded terminal of capacitor C-304.

b. Adjust R-307 (figure 4-2) until the voltage is exactly -300 volts.

c. Check, and if necessary, reset -1000-volt supply as described in paragraph 4-23.

4-23. REPLACING V-303 or V-306. Following replacement of V-303 or V-306:

a. Connect the negative lead of a d-c voltmeter with a sensitivity not less than 1000 ohms-per-volt to the -1000-volt bus (terminal 9, of the terminal board under resonator) and the positive lead to ground.

b. Adjust R-320 (figure 4-2) until voltage is exactly -1000 volts.

4-24. REPLACING V-308, V-309, V-310, V-311, or V-312. When replacing any one of these tubes:

a. Connect the negative lead of a d-c voltmeter with a sensitivity not less than 1000 ohms-per-volt to terminal 8 (-1500 volts) of the terminal board under resonator and the positive lead to terminal 9 (-1000 volts).

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b. Adjust R-335 (figure 4-2) until the meter indicates exactly -500 volts.

c. Following replacement of V-312 check klystron operating current as described in paragraph 4-15.

4-25. REPLACING V-313 or V-314. When replacing either of these tubes:

a. Connect the negative lead of a d-c voltmeter with a sensitivity not less than 1000 ohms-per-volt to the chassis and the positive lead to pin 3 of V-303.

b. Adjust R-338 (figure 4-2) until the voltage across resistor R-116 is a minimum (approximately 0.1 volt or less). Do not adjust but little beyond this minimum as doing so rapidly increases current through the modulator tube V-113, however it is important that the minimum be reached to assure klystron cutoff.

4-26. REPLACING CABINET.

4-27. To replace cabinet, place instrument with panel down. When the cabinet is being replaced, care must be taken to prevent the rubber baffle on side of instrument from being folded over by the edge of the cabinet, as it is lowered. This will require placing a sheet of thin metal or cardboard between the baffle and the cabinet until the edge of the cabinet passes over the baffle. When the cabinet is in place, securely tighten the four captive screws.

U. S. GOVERNMENT PRINTING OFFICE : 1971 O - 430-506 (6151A)

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